American Eel sampling at Conowingo Dam 2011

Steve Minkkinen, Ian Park, Maryland Fishery Resources Office, 1/25/2012

Background

Eels are a catadromous species that ascend freshwater environments as juveniles then reside in riverine habitats until reaching maturity at which time they migrate to the Sargasso Sea where they spawn once and die. Larval eels are transported by ocean currents to rivers along the eastern seaboard of the continent. Unlike anadromous shad and herring, they have no particular homing instinct. Historically, American eels were abundant in East Coast streams, comprising more than 25 percent of the total fish biomass in many locations. However, Atlantic coast commercial landings have been declining sine the 1970's.

The Atlantic States Marine Fishery Commission Fishery Management Plan for American Eel lists access to freshwater habitat as a priority for protecting the population. Although the Chesapeake Bay and tributaries support a large portion of the coastal eel population, eels have been essentially extirpated from the largest Chesapeake tributary, the Susquehanna River. The Susquehanna River basin comprises 43% of the Chesapeake Bay watershed. Construction of Conowingo Dam in 1928 effectively closed the river to upstream migration of elvers at river mile ten (Figure 1).

Mainstem Susquehanna fish passage facilities (lifts and ladder) were designed and sized to pass adult shad and herring and are not effective (due to attraction flow velocities and operating schedules) in passing juvenile eels (elvers) upriver. Specialized passages designed to accommodate elvers are needed to allow them access to the watershed above dams.

Survey methods and Equipment Placement

To determine the best method to reintroduce eels into the Susquehanna River above Conowingo Dam, we have collected baseline information on eel abundance, migration timing, catch efficiency, and attraction parameters at the base of the Conowingo Dam since the spring of 2005. Information from the study will assist in determining the potential for reintroducing eels into the Susquehanna watershed above Conowingo Dam.

The 2011 American eel sampling below Conowingo took place on the west side of the dam adjacent to the West Fish Lift. This sampling served as an attempt to further survey the population of juvenile eels (elvers) at the base of Conowingo Dam. In 2007, elvers were observed climbing up the rip rap where water was spilling over from pumps operated to supply water for the West fish lift operations. From 2008 through 2011 we used this excess water as attraction flow for our elver trap, constructed from industrial cable tray with landscape fabric attached to the bottom (Figure 2). Elvers that found this attraction flow would crawl up the rip rap to the trap and then climb into the trap. The top of the cable tray emptied into a fine mesh collection bag placed in collection tanks (Figure 3). Aerated water was supplied to the collection and holding tanks using a 1/8 HP Sweetwater™ Blower. In 2009 and 2010 we made an attempt

to attract elvers directly from the Susquehanna River at the base of the riprap as well. In 2011 we discontinued the experimental trap going down to the river's edge. Elvers were sedated with, Finquel Tricane Methanesulfonate (MS-222), measured for total length (TL), and individually counted. Large numbers of eels were counted volumetrically. The collection of substantial numbers of eels allowed for the experimental stocking of elvers into Buffalo Creek, Pine Creek and Conowingo Creek. Stocking in Buffalo Creek and Pine Creek is part of a compensatory mitigation for the Sunbury Riverfront Stabilization Project for the City of Sunbury (DA Permit Application Number: NAB 2005-02860-PO5) (attachment 1).

All of the elvers stocked were marked with a 6 hour immersion in buffered oxytetracycline (OTC) at a concentration of 550 ppm prior to release. A subsample of elvers captured was also sent to the Lamar Fish Health Center (Lamar, PA) for disease testing before any stocking occurred.

In previous years, eel pots with a 6 mm square mesh were set around the base of the West Fish Lift to catch larger eels. In 2011, we changed our collection device from a cylindrical eel pot to a double throated rectangular trap with a 25 mm by 13 mm mesh that is more consistent with local commercial gear. Yellow eels captured in eel pots were sedated with a concentrated solution of MS-222 (450g/L), measured, fin clipped, and had a Passive Integrated Transponder (PIT) tag inserted in the dorsal musculature and released.

In 2011, young-of-year (glass eels) were collected by Maryland Department of Natural Resources (Maryland DNR) in Turville Creek, MD. These eels were then transported to the United State Geological Survey lab in Wellsboro, Pennsylvania. The glass eels were held in the lab until June, and then released in Buffalo and Pine Creek (Table 1).

Results

Eels were sampled between 23 May and 8 September 2011 and elvers were collected throughout the sampling timeframe (Table 2). A total of 85,000 elvers were collected during 2011 with the majority collected in two pulses. The first wave occurred in the month of July and the second wave occurred at the end of August through the beginning of September during high flows associated with hurricane Irene and tropical storm Lee. Sampling ended abruptly due to flooding subsequently caused by tropical storm Lee. The seasonal pattern of migration in 2011 was similar to that observed in 2008 when a majority of the eel collection occurred in the end of June through the end of July. During 2009 the migration was later and more protracted with the majority of elvers being collected in the end of July through August. In 2008, 2010 and 2011 we saw multiple waves of elvers throughout our sampling efforts; where as in 2009 there did not appear to be spikes in collections, but more of a steady level of migration through the sampling period (Figure 4).

Juvenile eel lengths ranged from 84 to 225 mm TL (Figure 5), slightly larger than previous years sampling. In 2011, 75%of elvers measured were between 110 and 149 mm, and from 2005-2009 56% of elvers measured were between 110 and 149 mm.

Yellow and silver eel collections in eel pots have taken place from 2007 - 2011. In 2011, we caught 224 yellow and silver eels that ranged from 333 to 659 mm TL. Of the 224 captures, 127 eels had new PIT tags inserted, 55 were recaptures from tagging done in 2011 or in previous year, and the rest were released without being tagged. This year we caught significantly more yellow and silver eels than in previous years. The largest number of yellow and silver eels previously caught was in 2009, when we had 68 new captures (Table 3). The addition of the 127 new captures brings the total number of PIT-tagged yellow eels in the study to 289. We are tracking annual growth rates of the 31 PIT tagged eels that have been recaptured after at least one year after tagging (Table 4).

A total of ten stockings from elvers captured at Conowingo Dam were conducted, with an estimated total of 62,000 elvers being stocked in Buffalo, Pine and Conowingo Creek (Table 1).

To evaluate stocking success at Buffalo and Pine Creek, we conducted electrofishing surveys using 3 backpack shockers and a barge shocker in August 2011. We duplicated methods used by the Maryland Biological Stream Survey (2007) to quantify the catch per unit effort (CPUE) and the biomass of eels. Two sites, bracketing the eel release sites, in each creek were surveyed (Table 1). At each site, 75 meters of stream were blocked off using ¼" mesh block net. In order to quantify the fauna in the stream, two passes with the electrofishing units were conducted and all species of fish collected were enumerated. Captured eels were measured to assess growth and a subsample of the eels collected was brought back to confirm previous marking of otoliths by OTC. In August of 2011, 441 elvers were recaptured in Buffalo Creek. All but 9 of these were recaptured at the Strawbridge Rd site. An attempt was made to sample at the foot bridge on Rte. 1003 but high flows prevented a depletion study from being conducted. The average TL of stocked elvers from Conowingo was 127 mm, and the average TL of glass eels stocked was 80mm, while the average TL of recaptured eels in Buffalo Creek was 137 mm (Figure 6). Sampling Pine Creek in 2011 provided 20 recaptured elvers, 12 of which were recaptured at the Darling Run site, and the rest were caught at the Ansonia Bridge site. The average TL of recaptured eels in Pine Creek was 143 mm. In addition to eels, 4,854 individuals of 30 fish species were collected in Buffalo Creek and 3,663 individuals of 23 fish species were collected in Pine Creek during electrofishing surveys. (Minkkinen et al. 2011)

Maryland DNR conducts an American eel young of year (glass eel) survey to characterize trends in American eel recruitment over time (ASMFC 2000). Sampling takes place at Turville Creek, MD using a modified Irish elver ramp. We compared estimated recruitment of glass eels from Turville Creek to captures of elvers below Conowingo dam one year later. Based on four years of data it appears that the glass eel recruitment index at Turville Creek does predict elver abundance the following year at Conowingo Dam (Figure 7).

A subsample of elvers was sacrificed to evaluate the presence of the parasite *Anguillicola crassus*. A total of 46 eels were euthanized using MS-222, then examined for the presence of *Anguillicola crassus* in the swim bladder. The samples were collected in 2010 and 2011, with 19 samples from 2010 and 27 samples from 2011. *Anguillicola crassus* was found in 22 of the samples, with the highest infection rate of 6 being found in one eel. There does not appear to be any relation between the length of an eel and the infection rate (Figure 8) or an increase in infection rate from one year to the next.

Discussion

Throughout the project we have compared elver captures to several environmental factors. This year we increased the environmental factors analyzed. The factors we looked at were lunar fraction, river flow in Havre De Grace MD, barometric pressure, air temperature, daily precipitation levels, and the average daily values of dissolved oxygen, salinity, water temperature, pH, turbidity, and chlorophyll. In years past we have not been able to determine what environmental factors control the timing of the elver migration below Conowingo Dam. Typically elvers reach the dam between the first week of May through the end of June and peak captures usually occur in June and July. Using Pearson correlation it appears that turbidity, river flow and precipitation have the largest correlation value and these three values are directly related to one another (Table 5). With an increase of rain, for example the tropical storm that was observed this year, there was an increase in elver collection.

Interruptions in power supply to our pumps have impacted elver catch on several occasions. We have implemented several sampling design changes in an attempt to ensure that we would have an uninterrupted supply of water throughout the sample period. We have also increased the size of our collection and holding tanks in an effort to increase survival and decrease stress while holding the elvers for stocking. These measures have improved our ability to capture and hold larger numbers of elvers for stocking above the dam.

In 2012 we will attempt to release an additional 36,000 elvers in Pine Creek. We also will attempt to release elvers into Conowingo Creek in Maryland and Buffalo Creek in Pennsylvania. Elvers will be marked with OTC before being released. The Maryland Biological Stream Survey plans on conducting surveys in Conowingo Creek to evaluate the stocking effort. The Maryland Fishery Resources Office will survey elvers released in Buffalo Creek and Pine Creek using methods identical to those used in 2010 and 2011.

Figure 1. Map of the Maryland Biological Stream Survey (MBSS) sampling sites of tributaries to the Susquehanna River in Maryland. The numbers in boxes indicates eel counts at each sampling site. Note the difference in densities of eels in tributaries below Conowingo Dam compared to above the Dam.

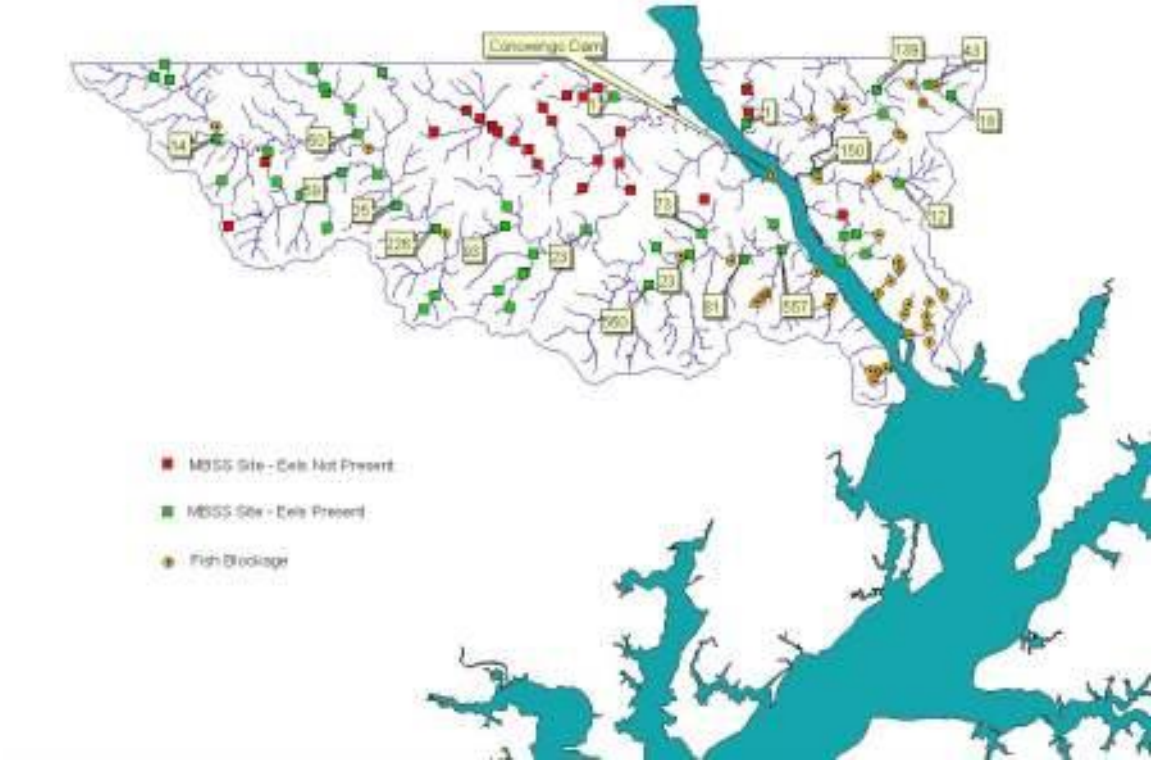

Figure 2. Eel trap constructed of industrial cable tray and landscape fabric.

Figure 3. The cable tray emptying into a collection bag in a holding tank.

Figure 4 Elver capture in relation to date for 2008 – 2011.

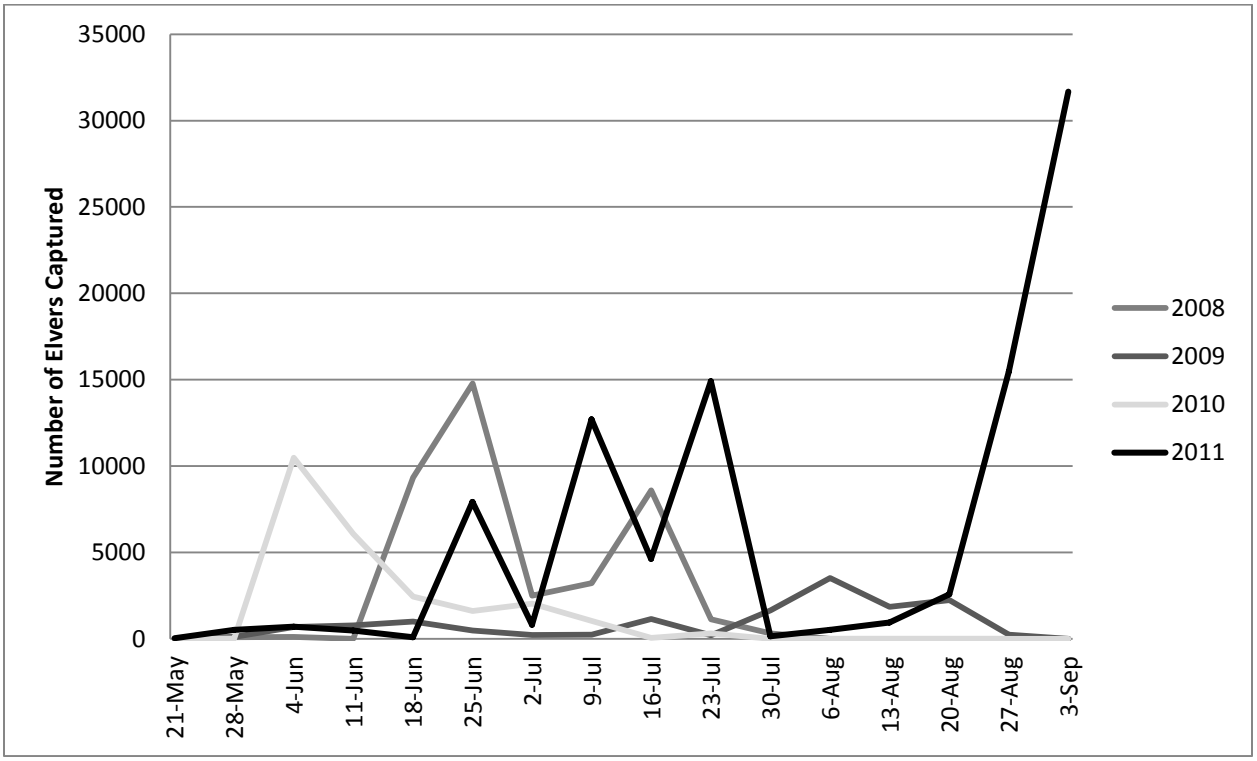

Figure 5 Length frequency of elvers captured below Conowingo Dam 2005-2011.

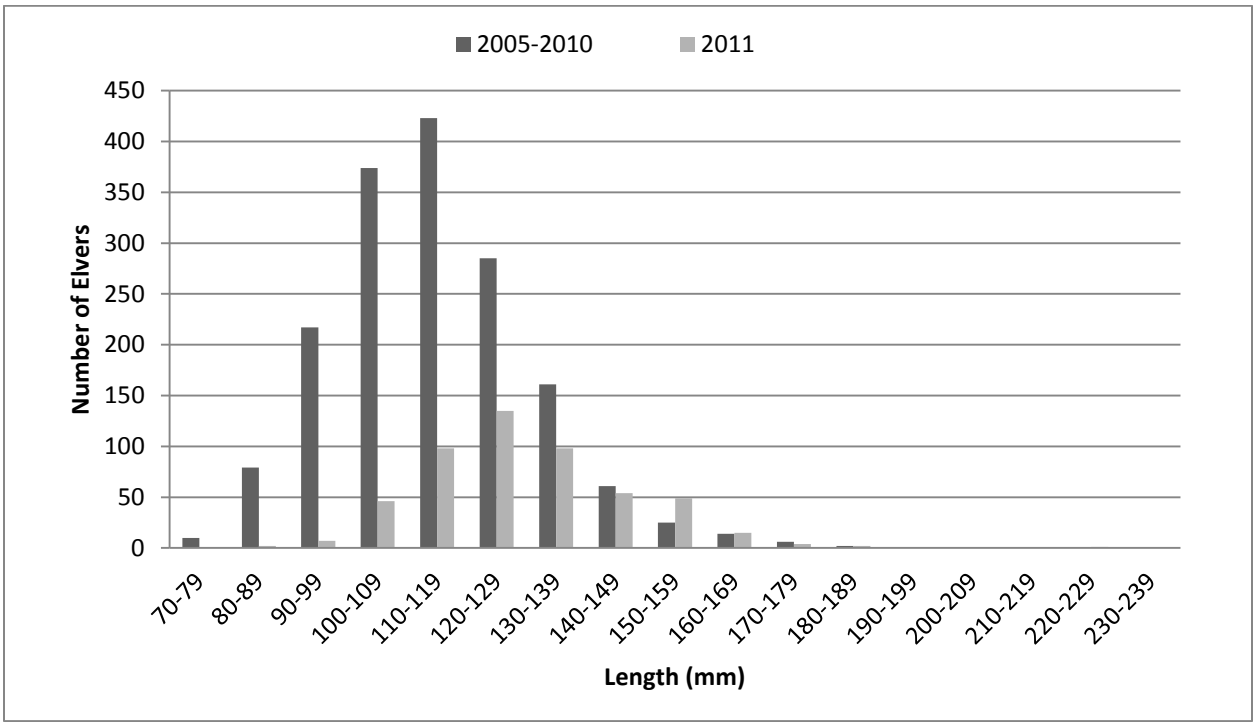

Figure 6 Length frequency of elvers recaptured in Buffalo Creek 2011

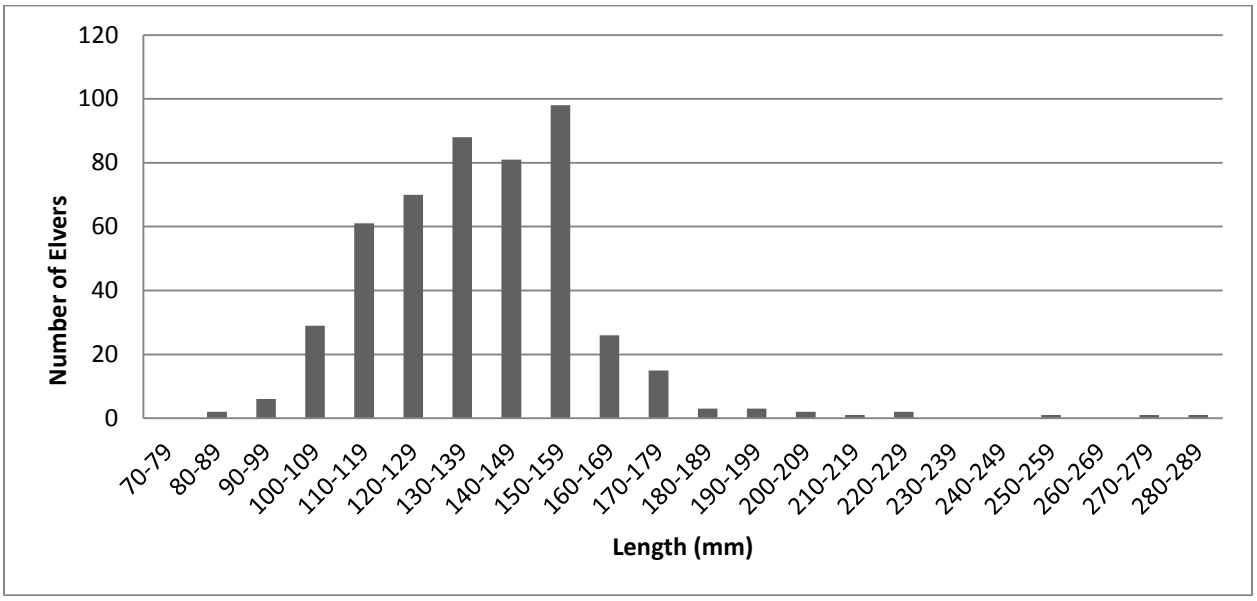

Figure 7 Yearly catch rates of glass eels from Turville Creek and elvers from Conowingo Dam

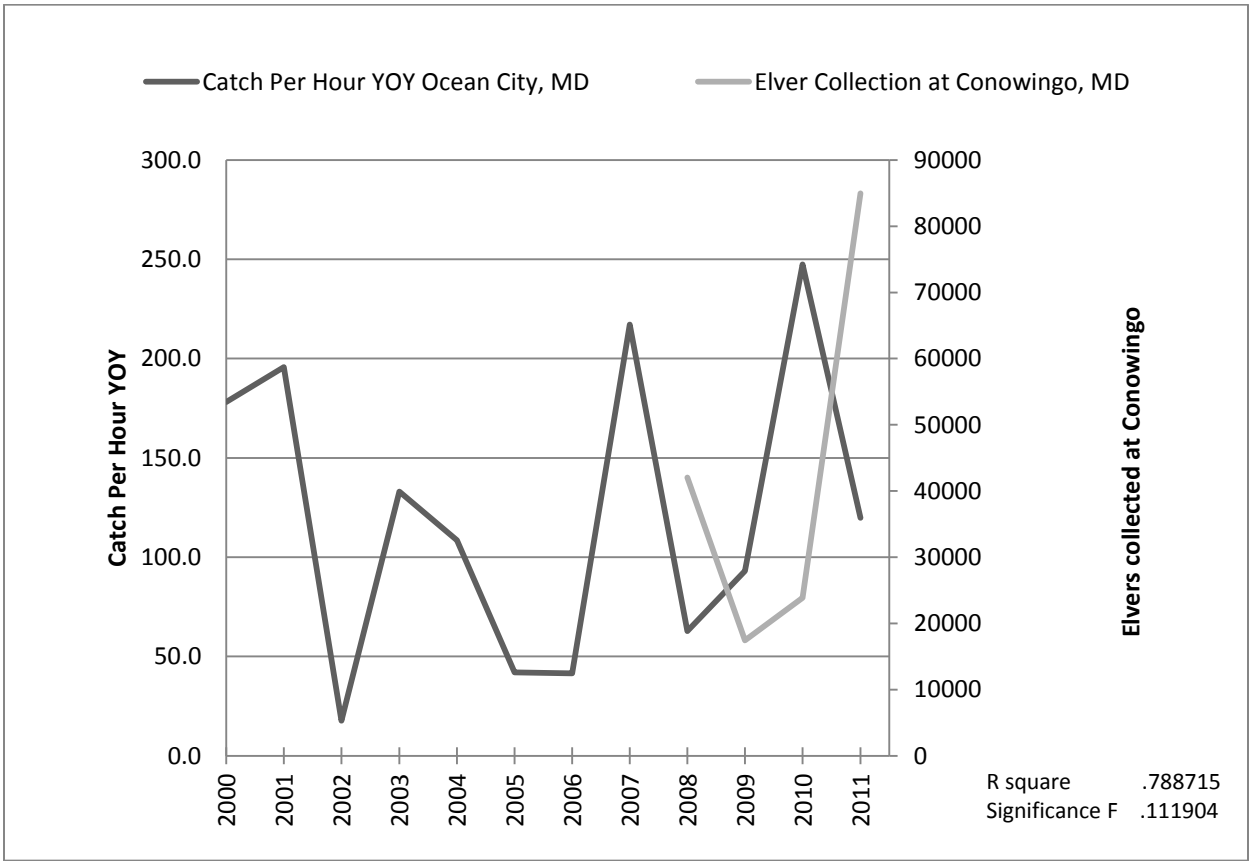

Figure 8 The number of *Anguillicola crassus* present in different lengths of elvers.

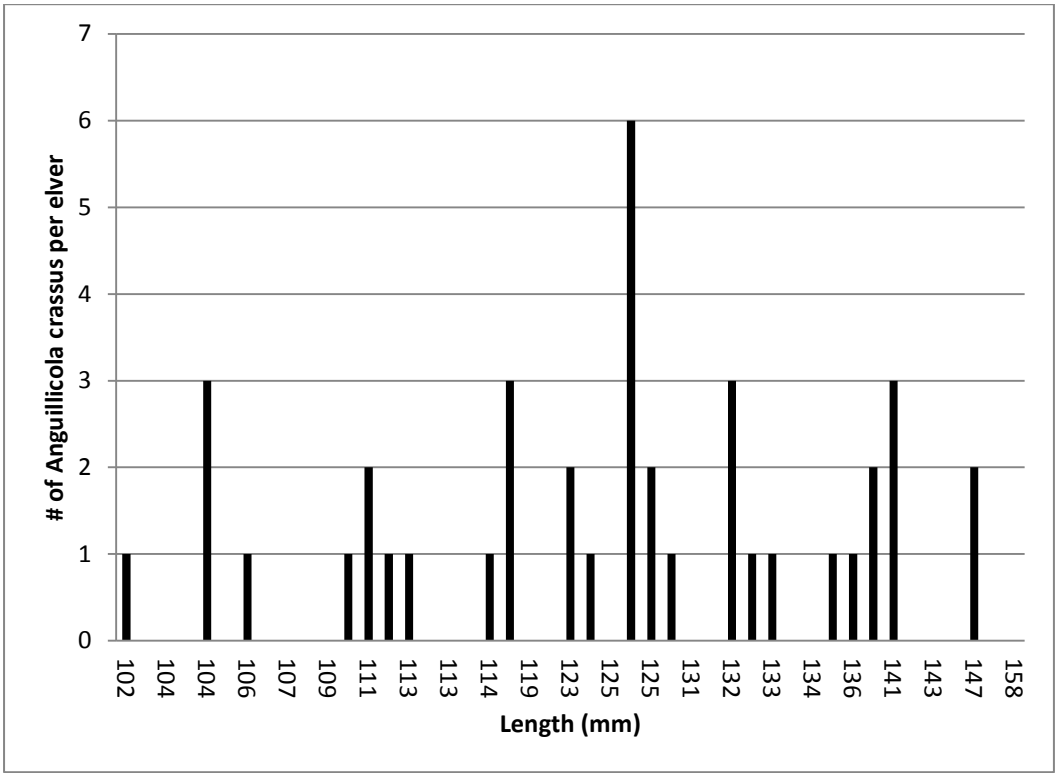

Table 1. Date, location, and number of elvers collected and stocked in 2011

STOCKING DATE	TOTAL ELVERS	STOCKING SITE	Latitude	Longitude	Origin
6/21/2011	16110	Buffalo Creek	40 58.864' N	76.57.081' W	Turville Creek
6/21/2011	16109	Buffalo Creek	40 59.139' N	76 55.930' W	Turville Creek
6/22/2011	10666	Pine Creek	41 44.633' N	77 26.031' W	Turville Creek
6/22/2011	10666	Pine Creek	41 16.285' N	77 19.894' W	Turville Creek
6/22/2011	10666	Pine Creek	41 44.203' N	77 25.822' W	Turville Creek
6/22/2011	1797	Conowingo Creek	39 43.852' N	76 10.701' W	Conowingo Dam
6/30/2011	7222	Pine Creek	41 44.633' N	77 26.031' W	Conowingo Dam
7/14/2011	6326	Buffalo Creek	40 59.139' N	76 55.930' W	Conowingo Dam
7/18/2011	4390	Buffalo Creek	40 59.139' N	76 55.930' W	Conowingo Dam
7/28/2011	3603	Buffalo Creek	40 59.139' N	76 55.930' W	Conowingo Dam
8/22/2011	1528	Pine Creek	41 44.633' N	77 26.031' W	Conowingo Dam
8/31/2011	8940	Pine Creek	41 44.633' N	77 26.031' W	Conowingo Dam
9/2/2011	8084	Pine Creek	41 44.633' N	77 26.031' W	Conowingo Dam
9/7/2011	12205	Pine Creek	41 44.633' N	77 26.031' W	Conowingo Dam
9/8/2011	7844	Conowingo Creek	39 43.852' N	76 10.701' W	Conowingo Dam

Table 2. Number of eels caught at the base of Conowingo Dam on the West side of the dam during 2011.

Date	# of Elvers		Date	# of Elvers
5/23/2011	34		7/20/2011	282
5/25/2011	8		7/22/2011	1380
5/27/2011	1		7/25/2011	2013
5/31/2011	41		7/27/2011	3603
6/3/2011	476		7/29/2011	34
6/6/2011	511		8/1/2011	87
6/8/2011	70		8/2/2011	16
6/10/2011	121		8/5/2011	58
6/13/2011	382		8/8/2011	250
6/15/2011	79		8/10/2011	126
6/17/2011	21		8/12/2011	149
6/20/2011	71		8/15/2011	257
6/22/2011	6		8/17/2011	184
6/24/2011	21		8/19/2011	506
6/27/2011	1217		8/22/2011	928
6/29/2011	4467		8/24/2011	850
6/30/2011	1817		8/26/2011	797
7/1/2011	439		8/29/2011	1344
7/3/2011	378		8/30/2011	2648
7/5/2011	162		8/31/2011	3358
7/7/2011	288		9/1/2011	3548
7/11/2011	1132		9/2/2011	4573
7/12/2011	5514		9/3/2011	3880
7/13/2011	1660		9/4/2011	7250
7/14/2011	2074		9/6/2011	6275
7/15/2011	2340		9/7/2011	6424
7/16/2011	2187		9/8/2011	7844
7/18/2011	780			

Table 3. Number of Passive Integrated Transponder Tags (PIT) applied to yellow eels by year.

Year	# of Tags Applied
2007	51
2008	32
2009	68
2010	11
2011	127

Table 4. Growth of yellow eels caught and recaptured in pots at the base of Conowingo dam by year.

	Average Length (mm)					*Average Annual Growth Increase (mm)*
ID	**2007**	**2008**	**2009**	**2010**	**2011**	
257C63E092	594	617	*	*	*	23
257C6534CA	733	770	*	*	*	37
257C6526C0	463	474	*	*	*	11
257C65EB48	404	510	521	*	*	58.5
257C655F24	426	445	*	*	*	19
257C65F2F2	338	390	505	*	*	83.5
257C63E581	551	589	*	*	*	38
257C65F8B0	475	511	*	*	*	36
257C65E87B	405	471	510	*	*	55
257C65FBAB	377	405	440	*	*	31.5
257C652B3A	466	490	*	*	*	24
257C63C580	391	520	*	557	*	55.3
257C660193	386	428	*	*	*	21
257C63CE9A	458	*	565	*	*	53.5
257C63CF54	484	*	624	*	*	70
257C652735	457	*	590	*	*	66.5
257C6534A4	386	*	478	*	*	46
257C66192F	447	*	580	*	*	66.5
257C63D36E	*	419	433	*	*	14
257C652BF4	*	364	383	395	449	28.3
257C65342C	*	393	516	*	*	123
257C65B1E0	*	479	543	*	*	64
257C660279	*	497	575	*	*	78
257C65E54F	*	454	*	550	*	48
1C2D05239A	*	*	612	626	*	14
1C2D0529B9	*	*	495	578	*	83
257C63D39B	*	*	432	462	470	19
257C6553FB	*	335	*	*	446	37
257C655957	*	321	*	*	377	18.6
1C2D05286B	*	*	476	*	508	16
1C2D052453	*	*	368	*	465	48.5

Table 5 Pearson Correlation performed on number of elvers captured and environmental variables

	# eels	*Lunar Fraction*	*Avg. Att Flow*	*Barrometric Pressure*	*Air Temp*	*Precipitation Sum*	*AVG of DO (conc.)*	*AVG of Salinity (ppt)*	*AVG of Temp (°C)*	*AVG of pH*	*AVG of Turbidity (NTU)*	*AVG of Chlorophyll a (µg/l)*
# eels	1											
Lunar Fraction	0.0260	1										
AVG Flow	0.4241	0.0330	1									
Barrometric Pressure	0.1454	-0.2805	0.1595	1								
Air Temp	-0.2163	0.0302	-0.2621	-0.4116	1							
Precipitation	0.3088	0.0424	0.2415	0.0207	-0.3217	1						
AVG of DO	-0.0735	-0.1243	0.2647	0.2474	0.0248	-0.1219	1					
AVG of Salinity	-0.2894	-0.0734	-0.5819	-0.1535	0.1199	-0.1368	-0.5397	1				
AVG of Temp	-0.2502	0.0874	-0.6924	-0.2893	0.5639	-0.1738	-0.3882	0.6475	1			
AVG of pH	-0.5675	-0.1282	-0.3780	-0.0321	0.2888	-0.2476	0.6206	-0.0170	0.3254	1		
AVG of Turbidity	0.6111	0.1400	0.8525	0.0083	-0.1800	0.2524	0.0581	-0.4502	-0.4174	-0.4150	1	
AVG of Chlorophyll a	-0.1177	-0.4422	0.2031	0.1431	-0.0758	-0.0637	0.6783	-0.3313	-0.2645	0.6269	0.1055	1

REFERENCES

ASMFC (Atlantic States Marine Fisheries Commission). 2000. Standard procedures for American eel young of the year survey.

Maryland DNR. 2007. Maryland Biological Stream Survey: Sampling Manual Field Protocols. 65 pp.

Minkkinen S.P., Devers J.L. & W.A. Lellis. 2011. Experimental Stocking of American Eels in the Susquehanna River Watershed. Report of U.S. Fish and Wildlife Service to City of Sunbury, Pennsylvania.